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(54) **LOW PROFILE CONNECTOR SYSTEM**

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H01R 11/22	(2006.01)
H01R 13/631	(2006.01)
A61N 1/04	(2006.01)

(Continued)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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USPC 439/268, 859, 860, 869, 631, 639; 600/391, 393

See application file for complete search history.

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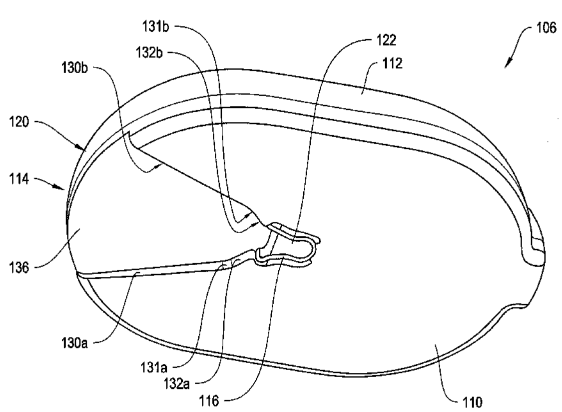
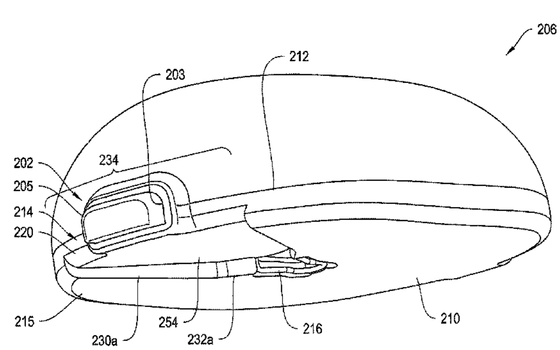
(74) *Attorney, Agent, or Firm* — Knobbe Martens Olson & Bear LLP

(57) **ABSTRACT**

A low-profile electrical connector includes a housing having exterior perimeter sides and top and bottom surfaces, where the bottom surface is configured to extend along a user's body site and the top surface is spaced above the bottom surface. The connector also includes a side-entry guide channel disposed along the bottom surface. The channel includes an opening along the exterior perimeter side that is configured to receive an electrically conductive element. The channel is also configured to guide the electrically conductive element within the housing. The connector includes a receptacle positioned within the housing and forms an electrically conductive interface with the electrically conductive element.

19 Claims, 19 Drawing Sheets





(51) **Int. Cl.**

A61N 1/36	(2006.01)
H01R 13/502	(2006.01)
H01R 13/635	(2006.01)

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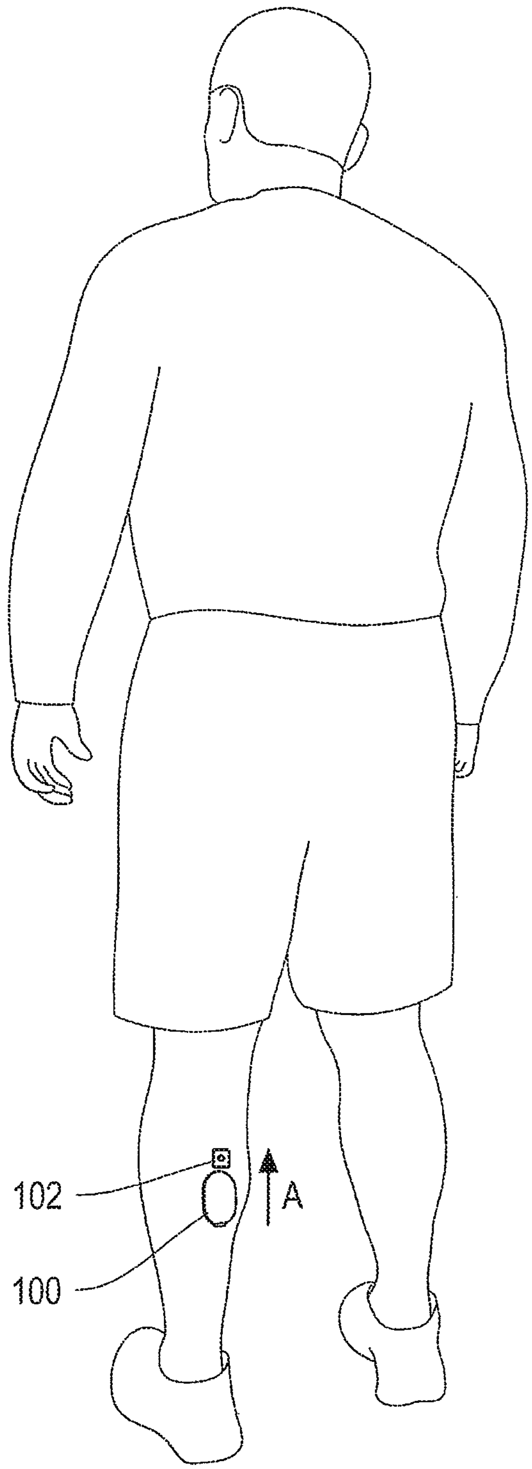


FIG. 1A

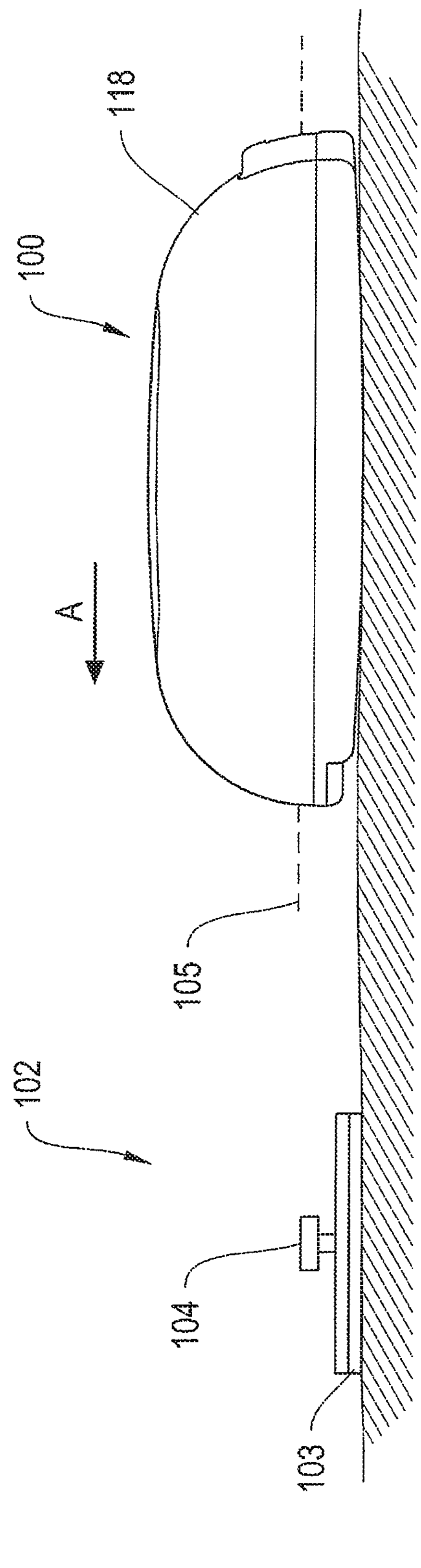


FIG. 1B

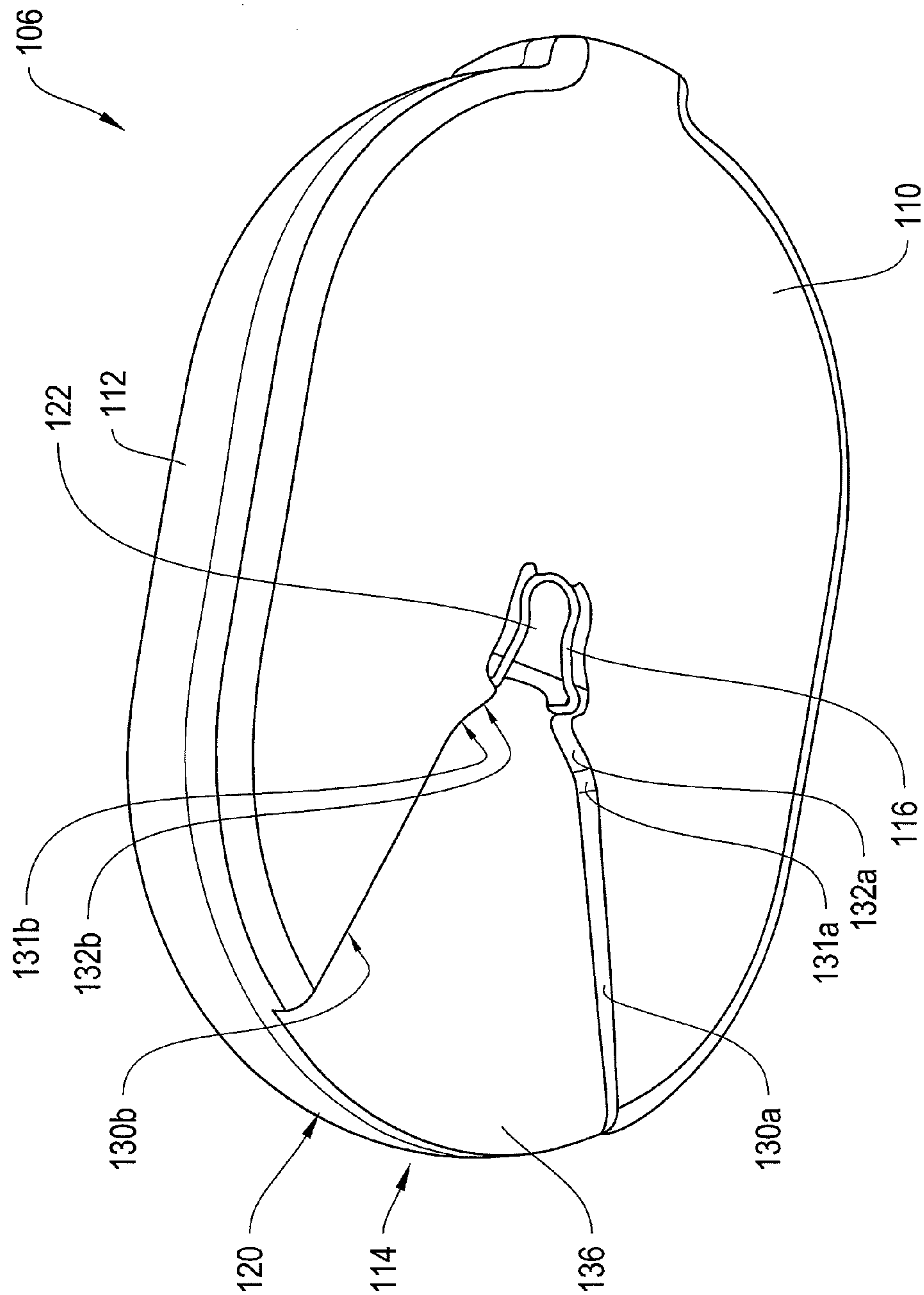


FIG. 2A

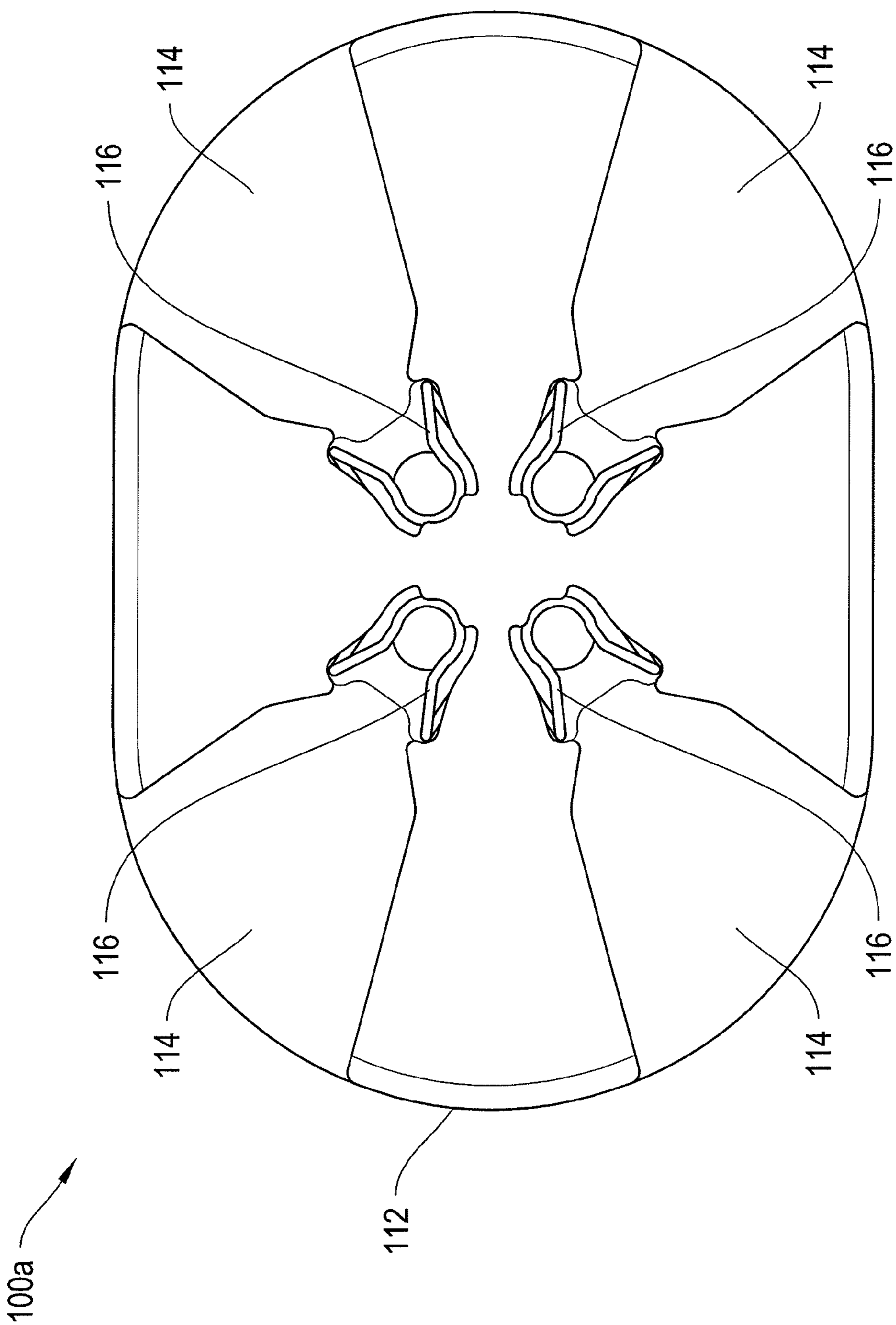


FIG. 2B

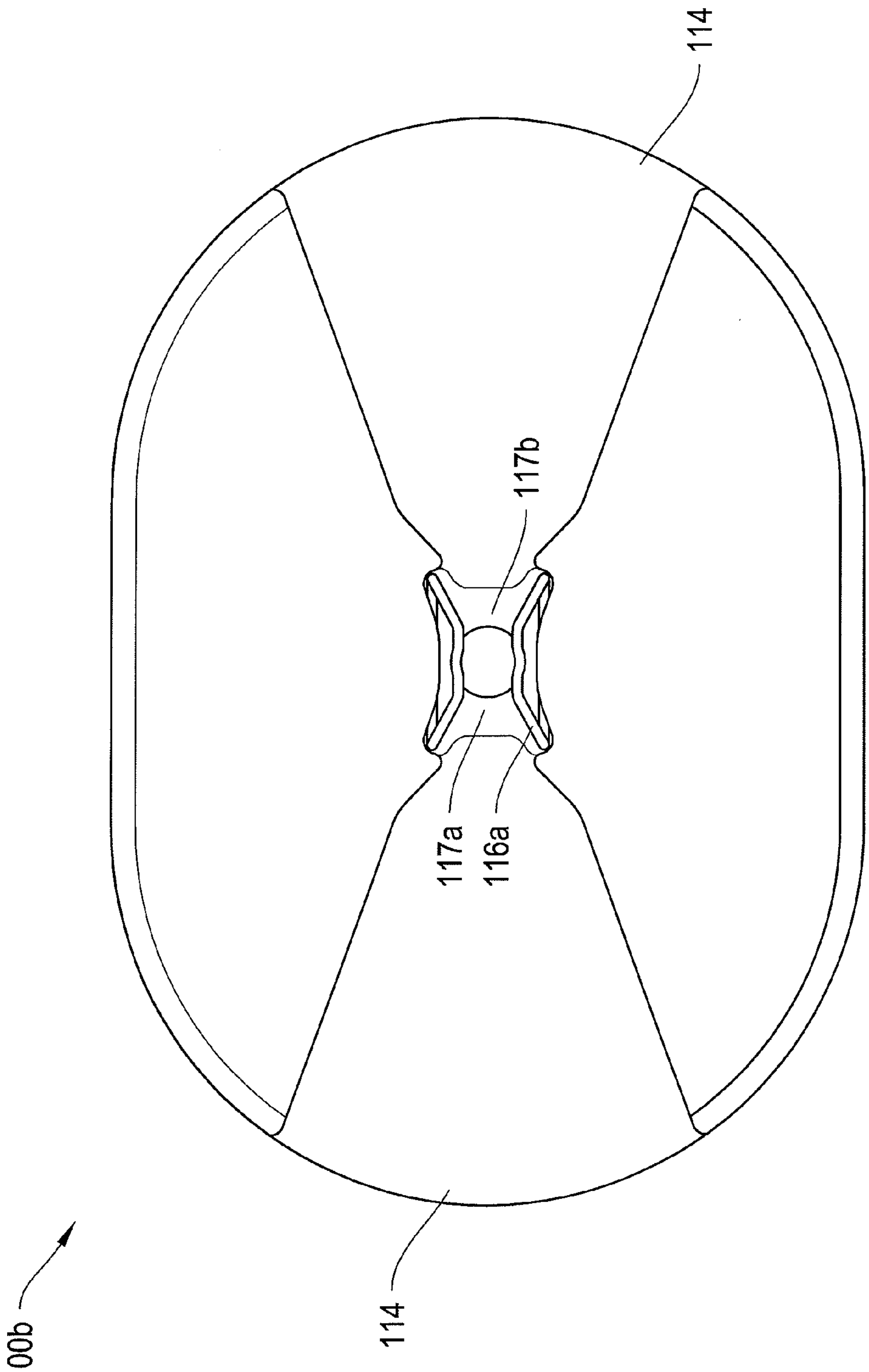


FIG. 2C

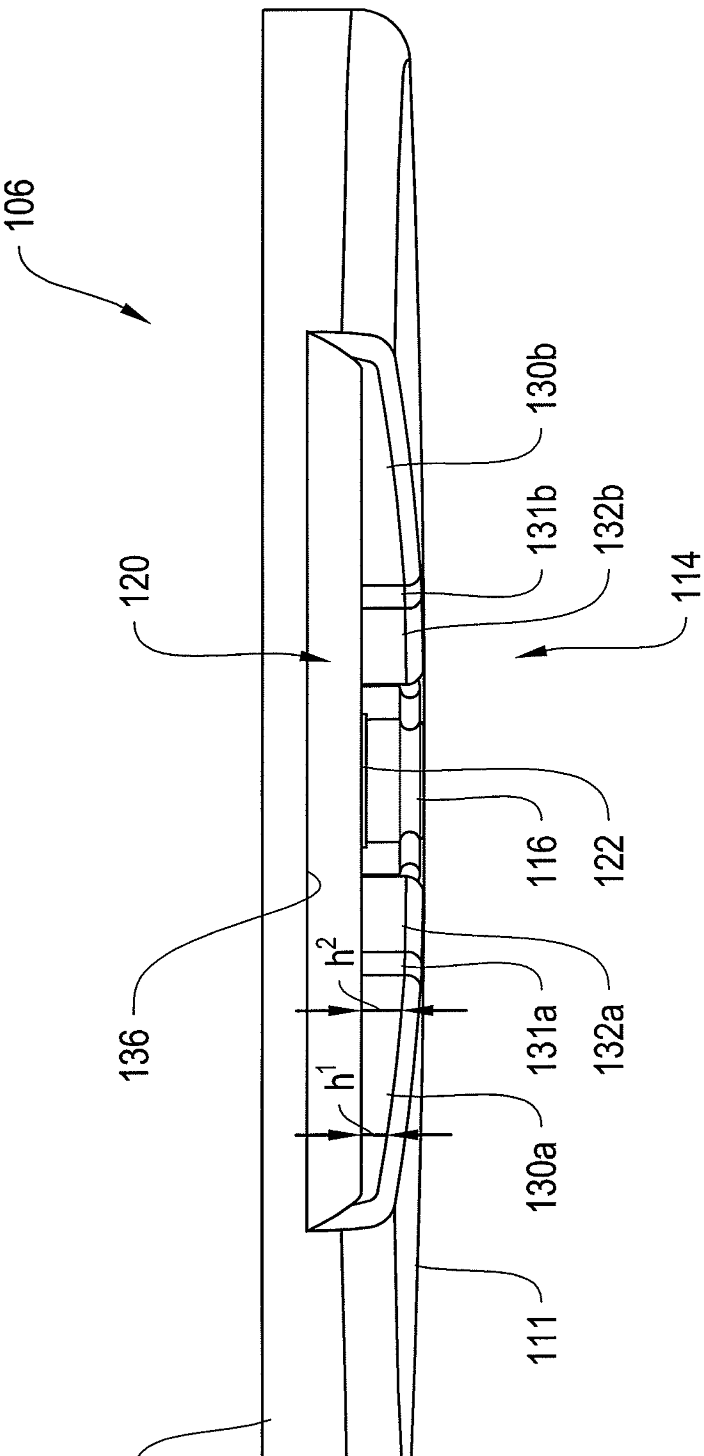

106
130b
131b
132b
120
114
116
122
136
h2
h1
131a
132a
130a
111
112

FIG. 3

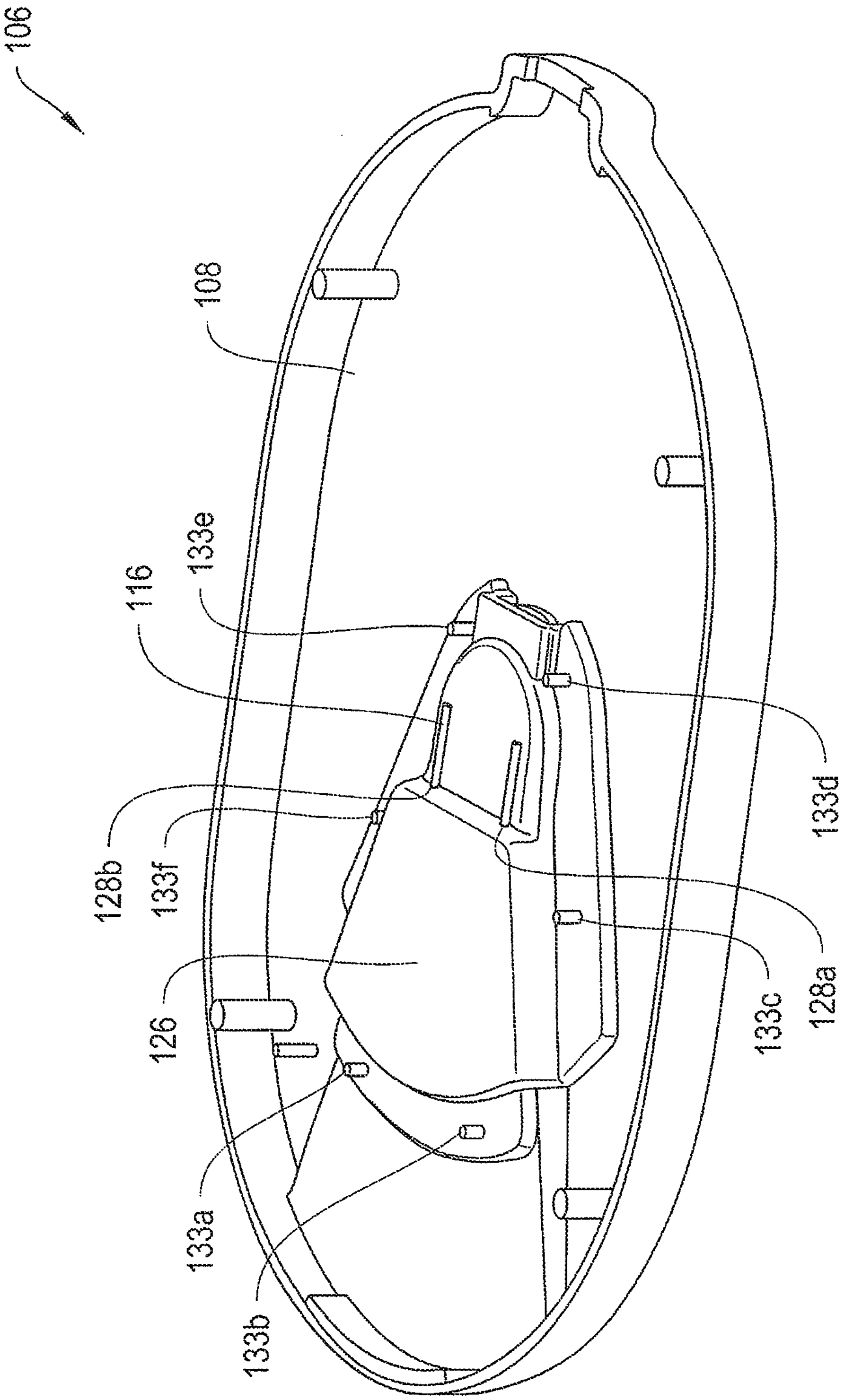


FIG. 4

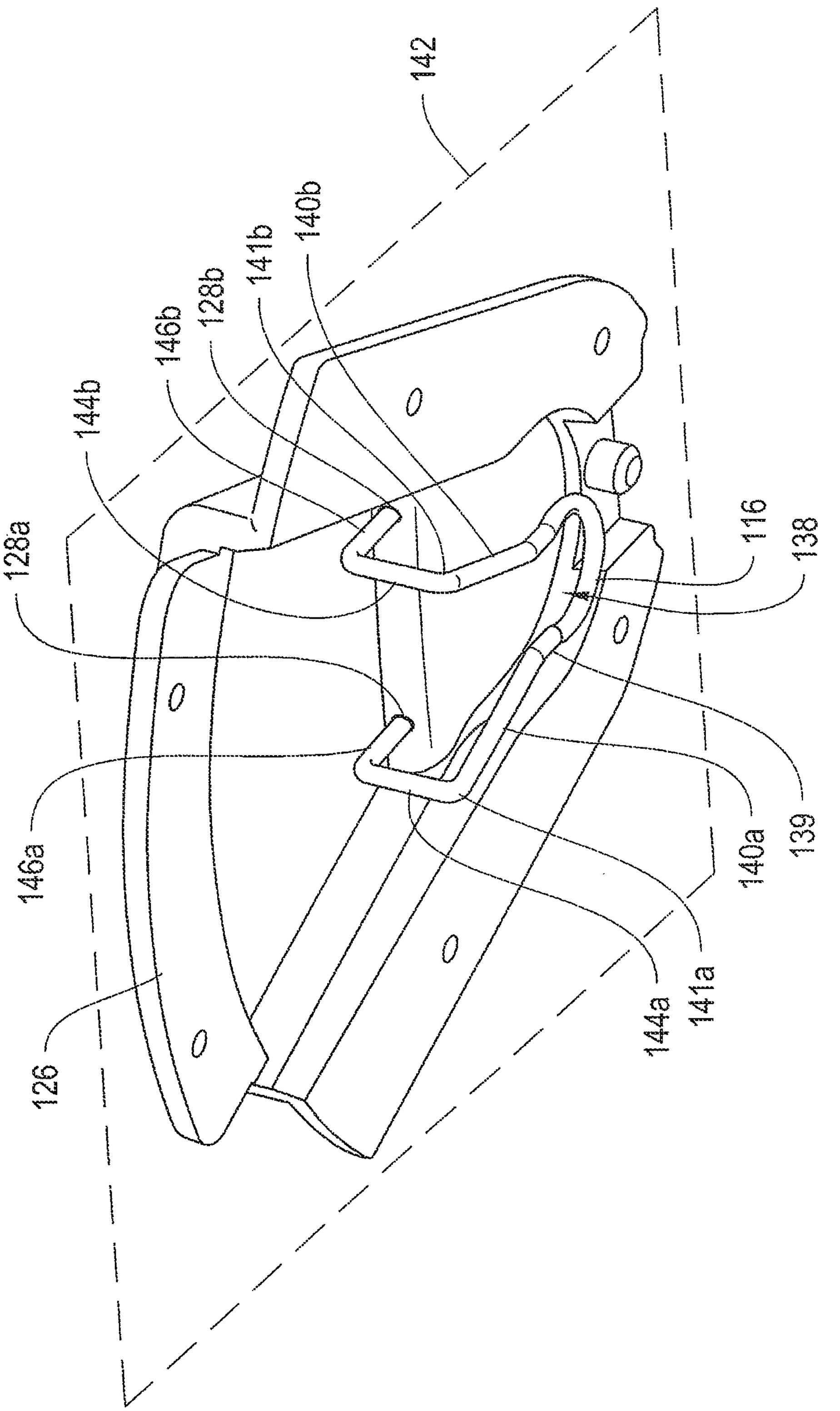

142
140b
141b
128b
146b
144b
128a
116
138
140a
139
146a
144a
141a
126

FIG. 5

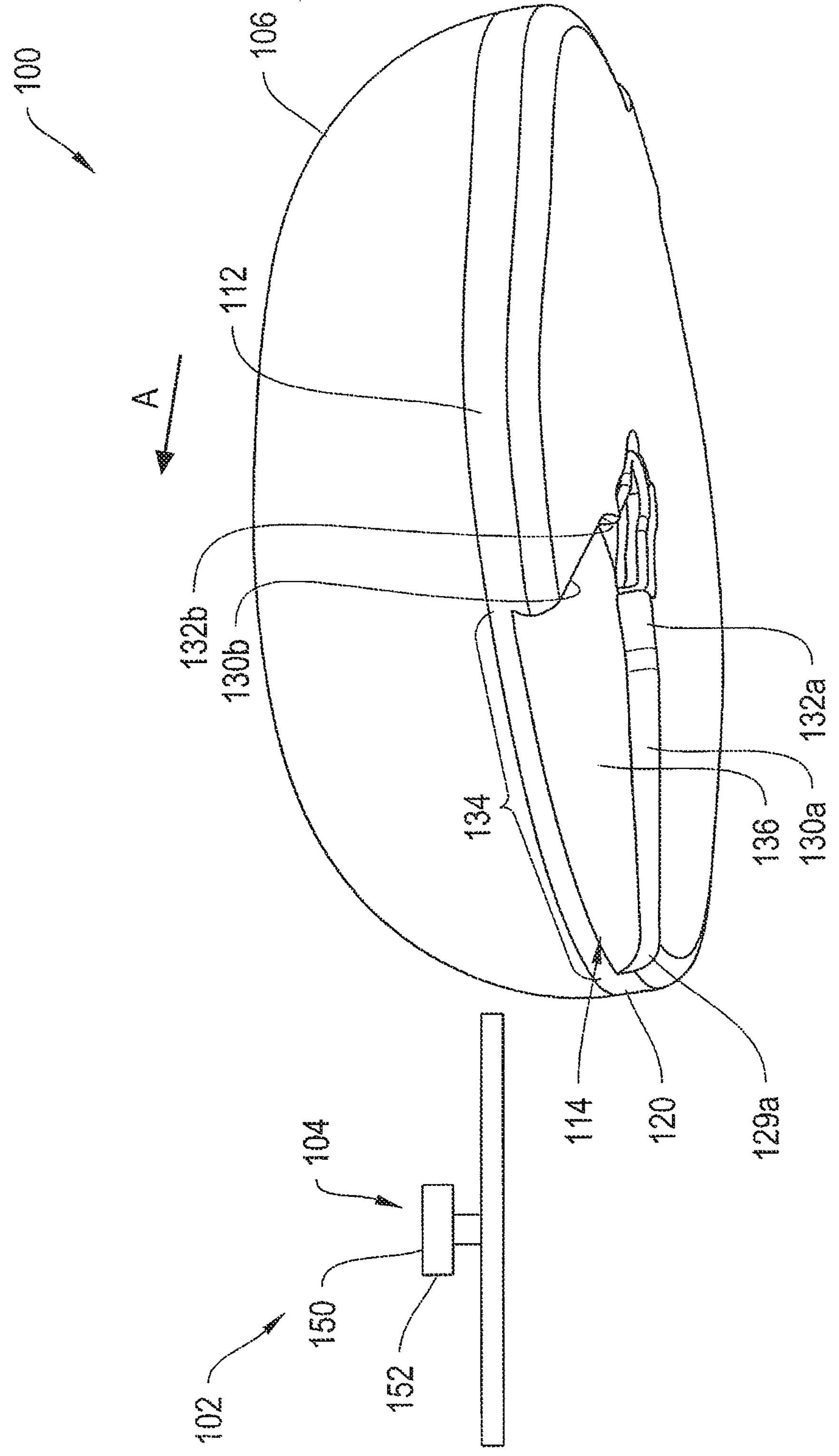

100
106
112
A
132b
130b
132a
130a
136
134
114
120
129a
104
150
152
102

FIG. 6A

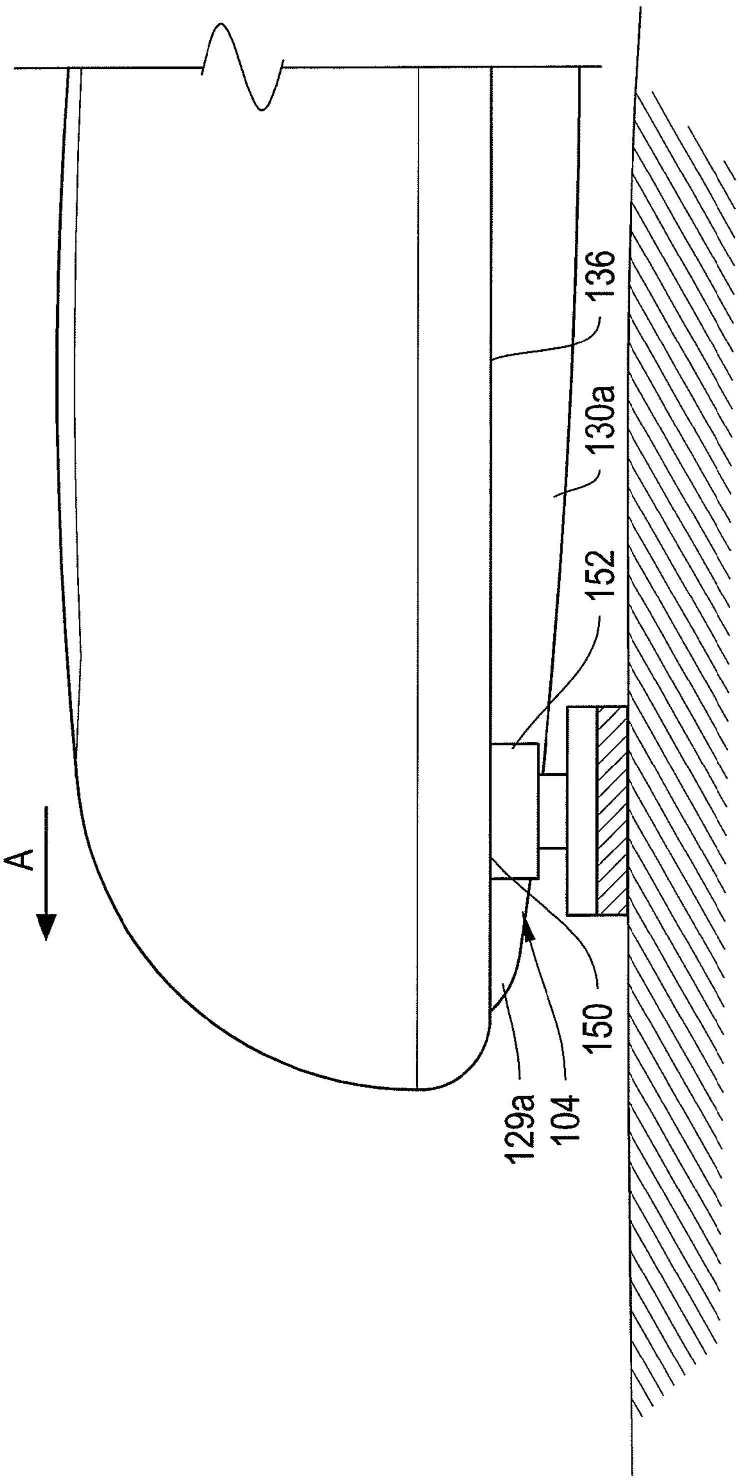


FIG. 6B

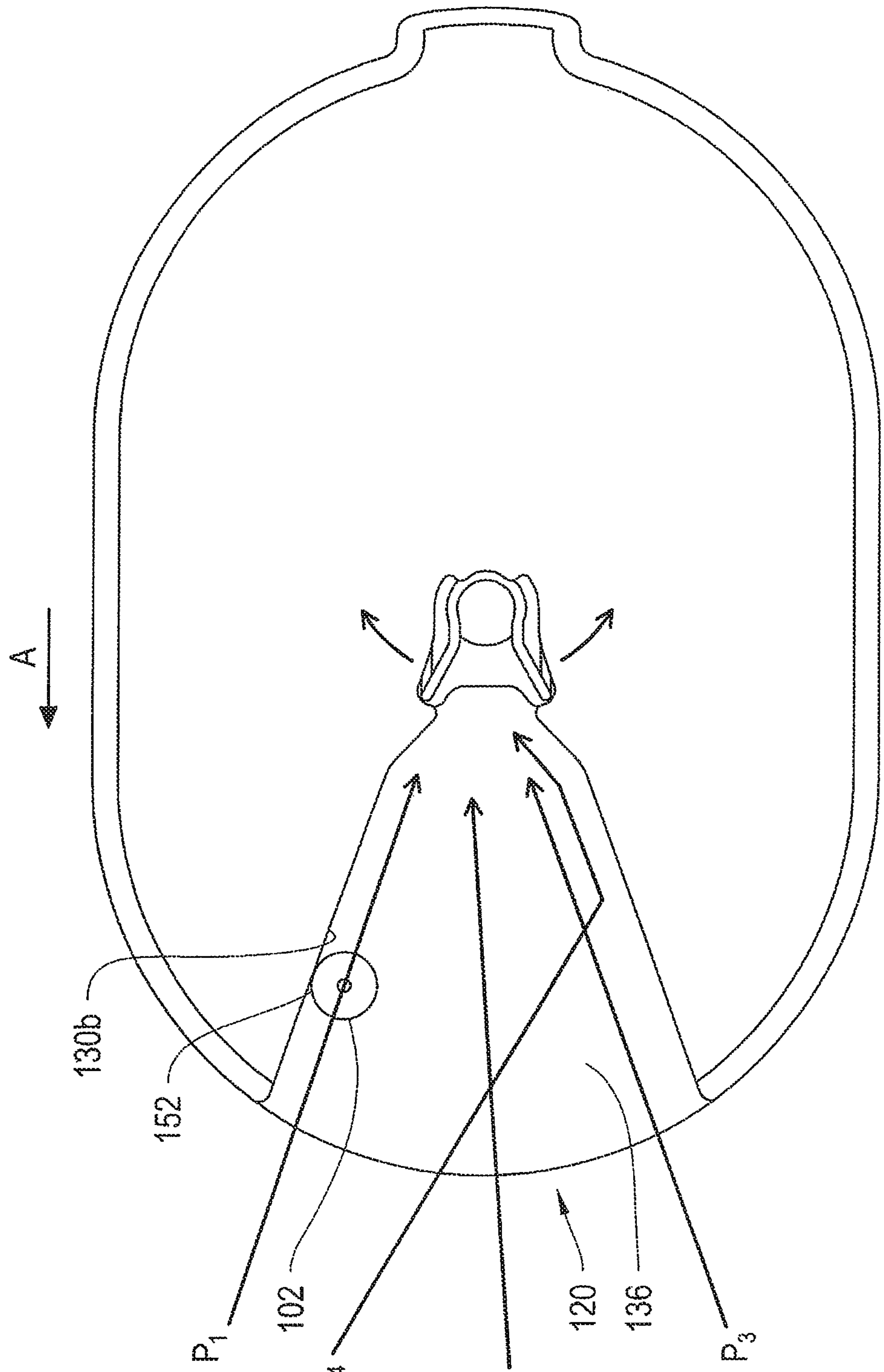


FIG. 6C

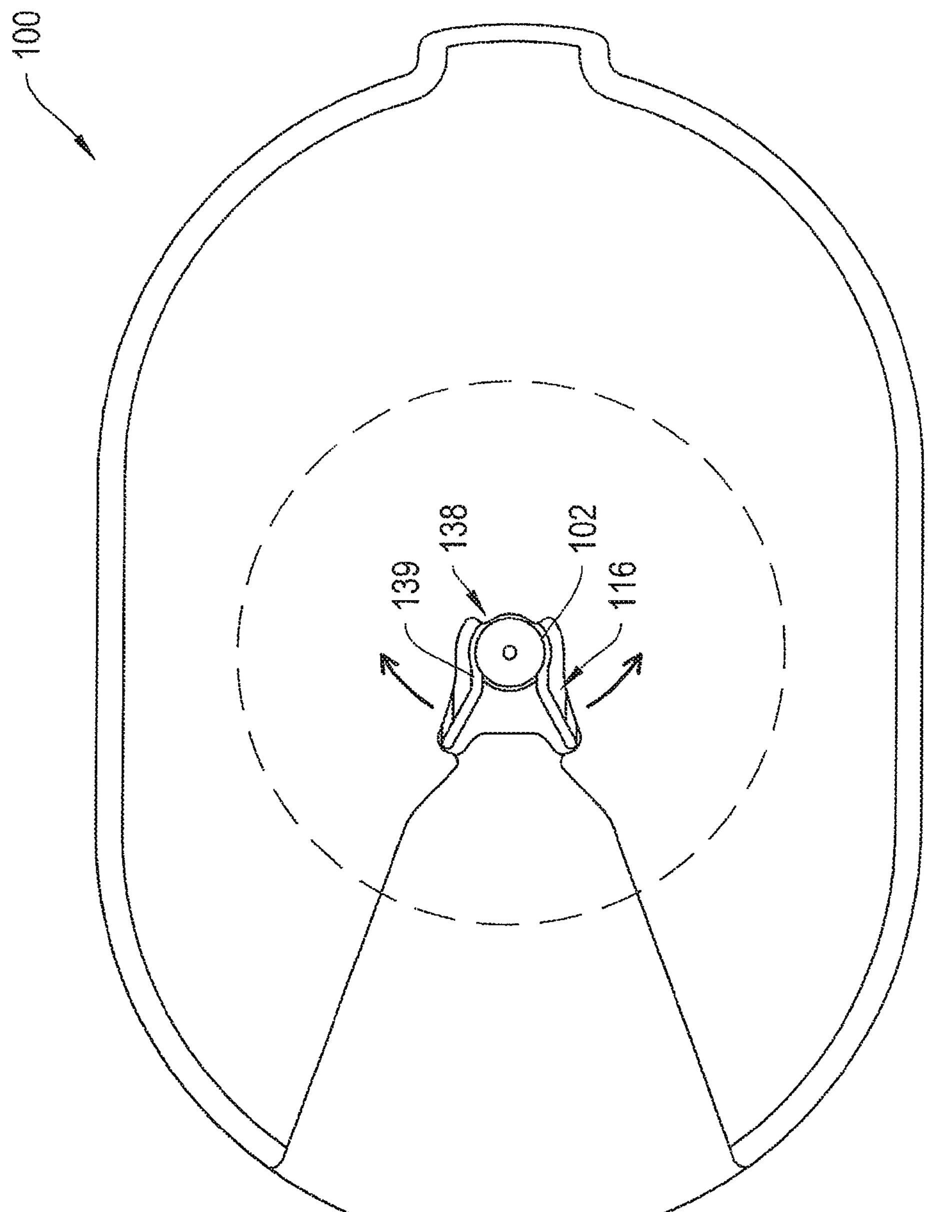


FIG. 7

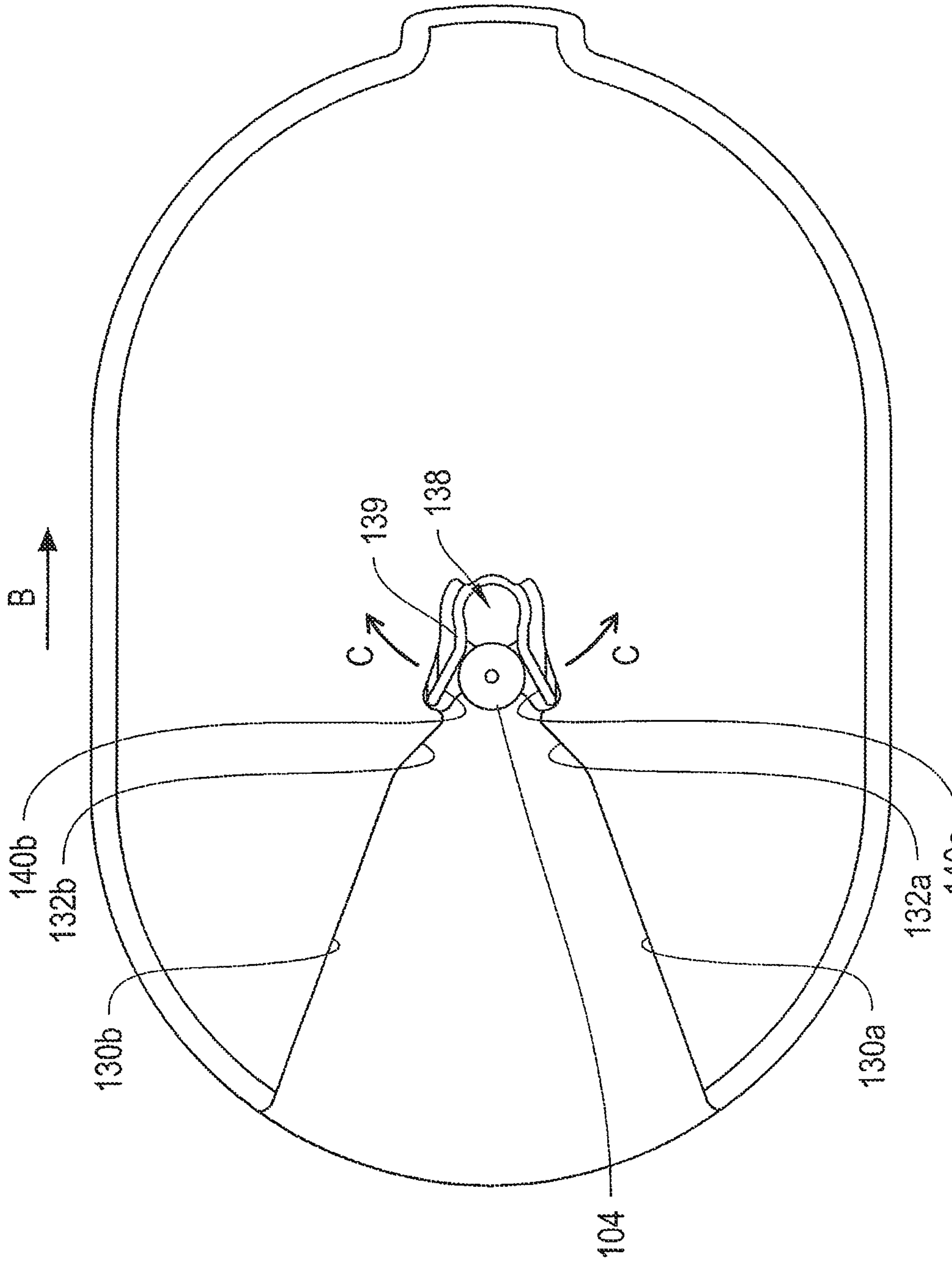


FIG. 8

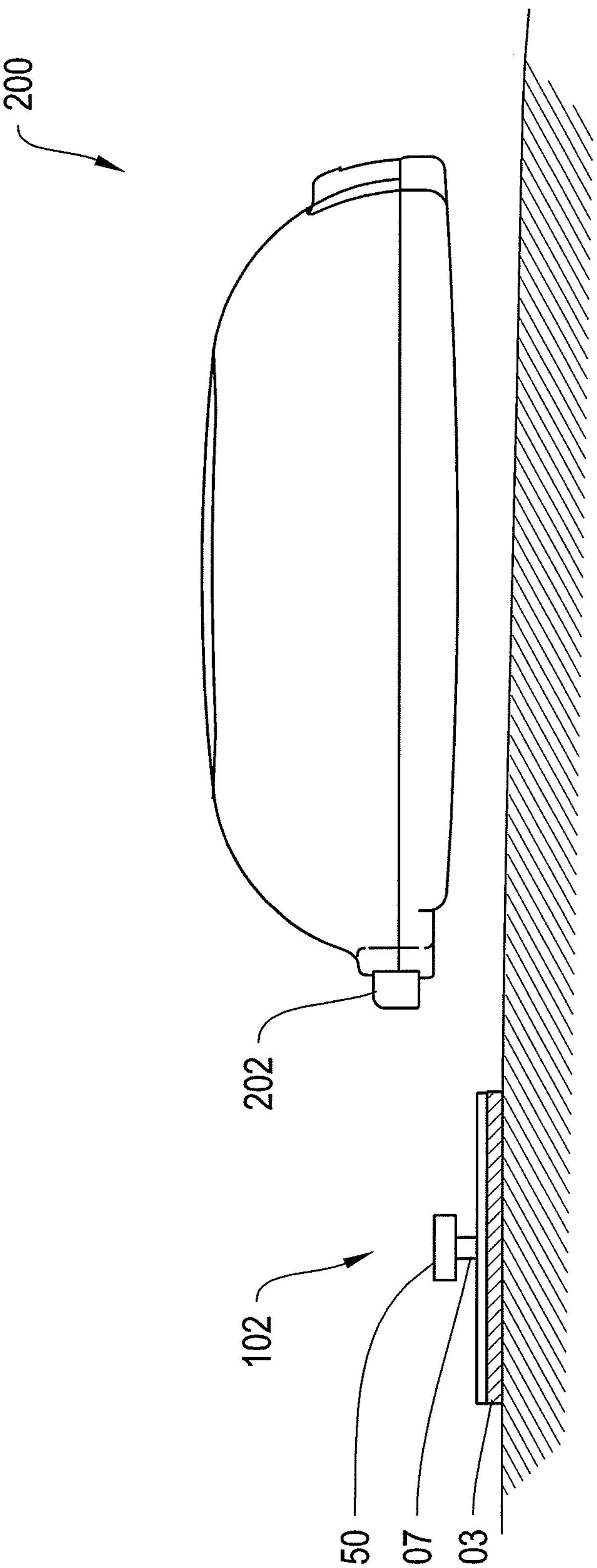


FIG. 9A

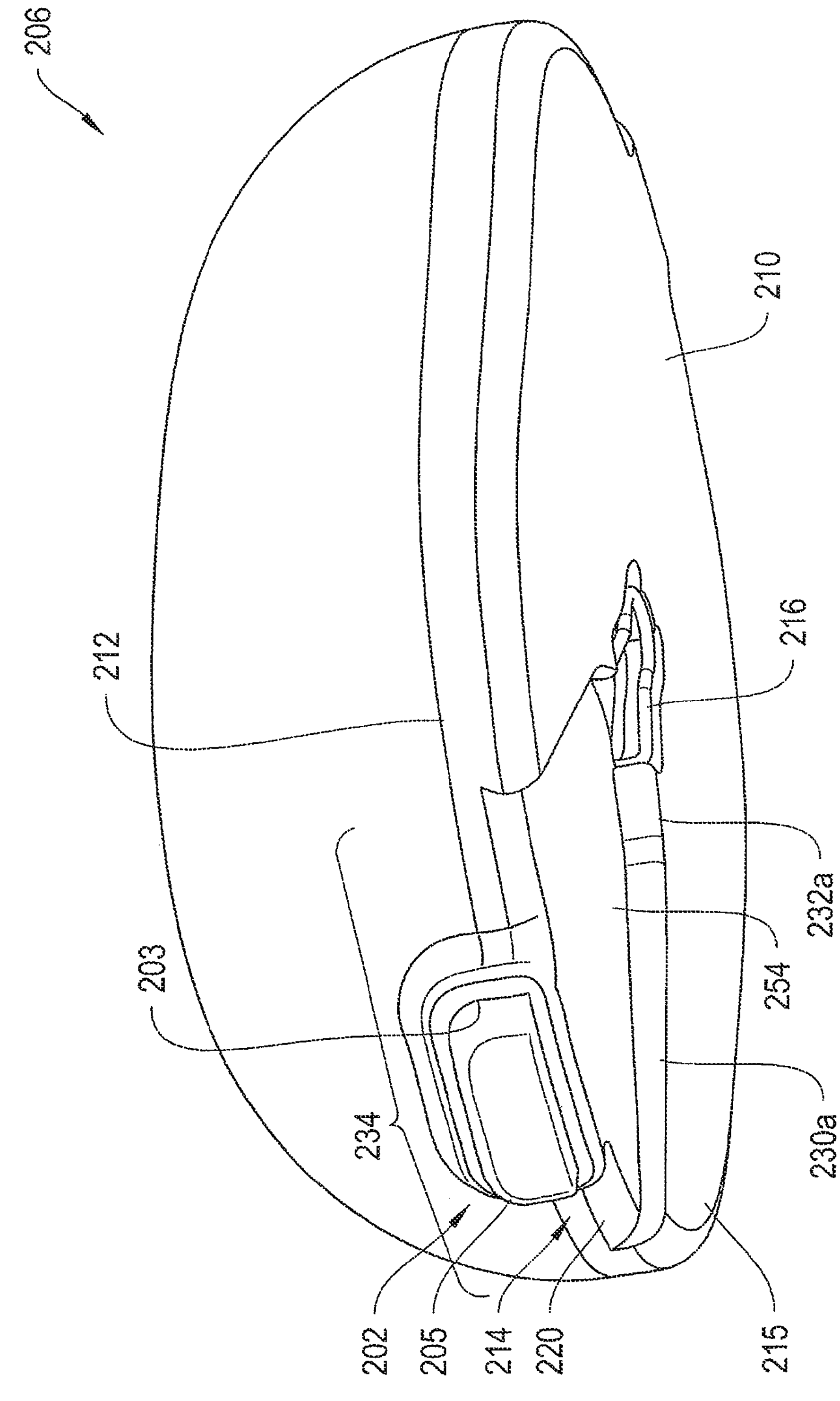


FIG. 9B

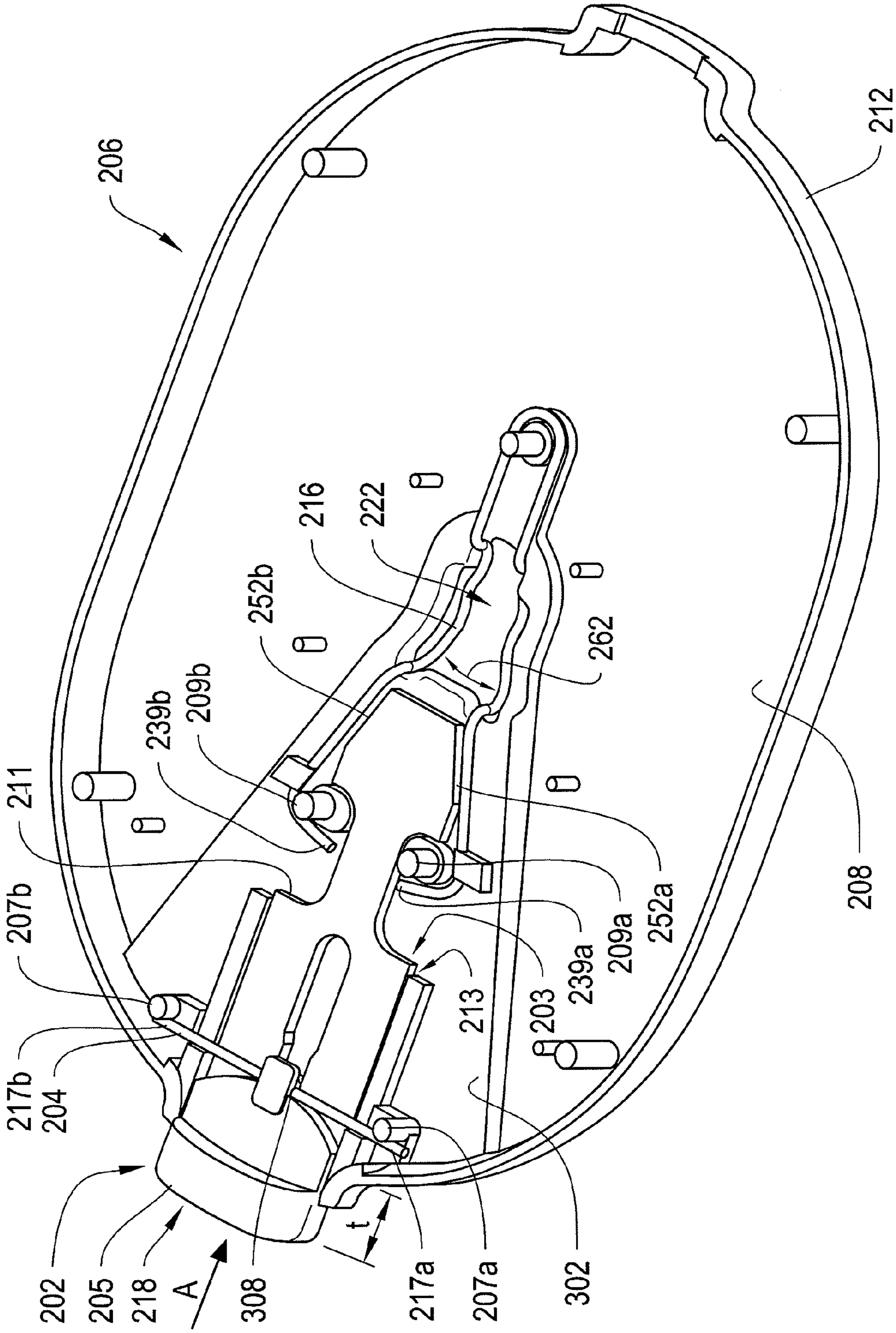
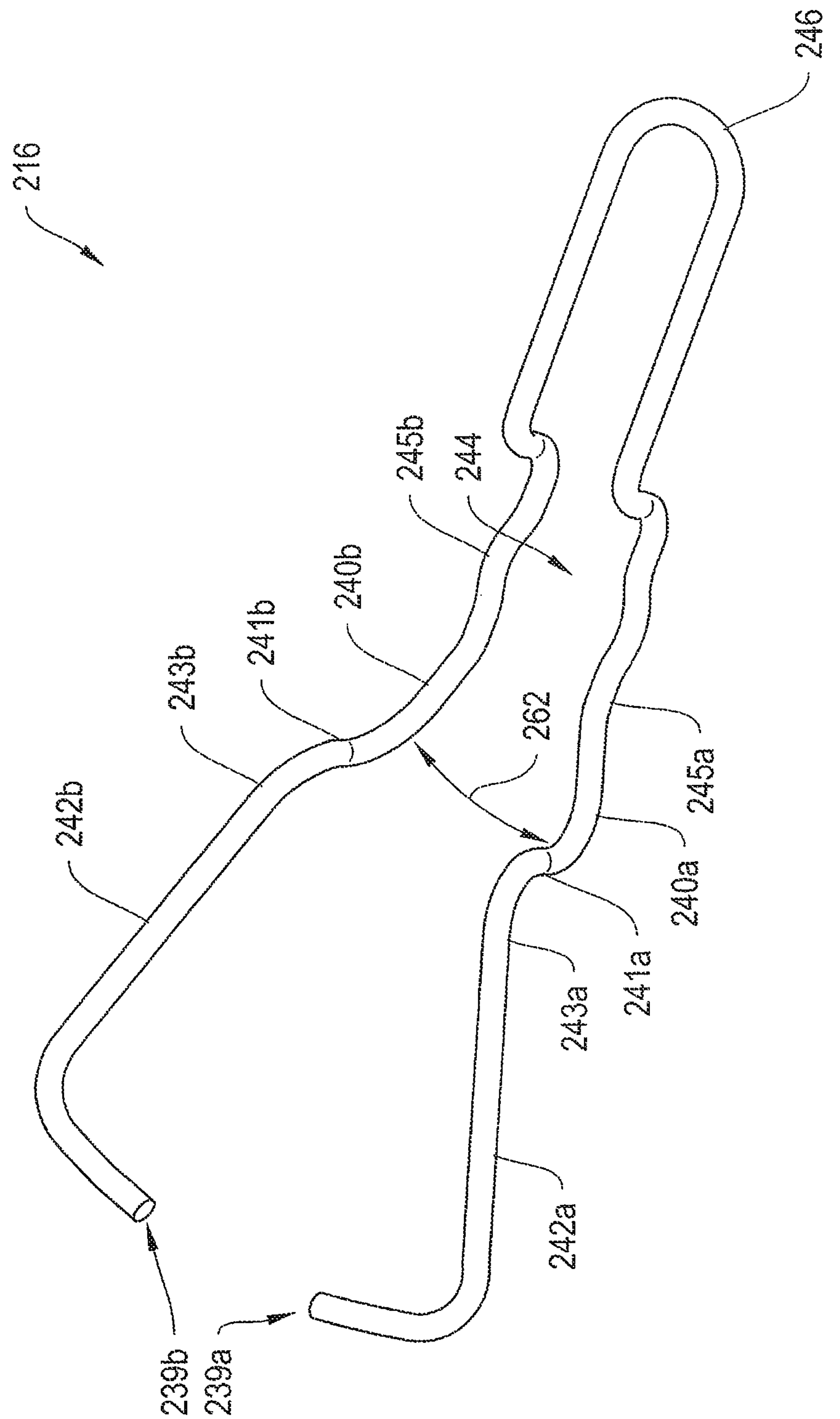

206
212
216
222
252b
262
239b
209b
211
207b
217b
204
209a
239a
252a
203
213
208
202
205
218
A
308
t
217a
207a
302

FIG. 9C



216
246
245b
244
240b
241b
243b
262
245a
240a
242b
241a
243a
242a
239b
239a

FIG. 9D

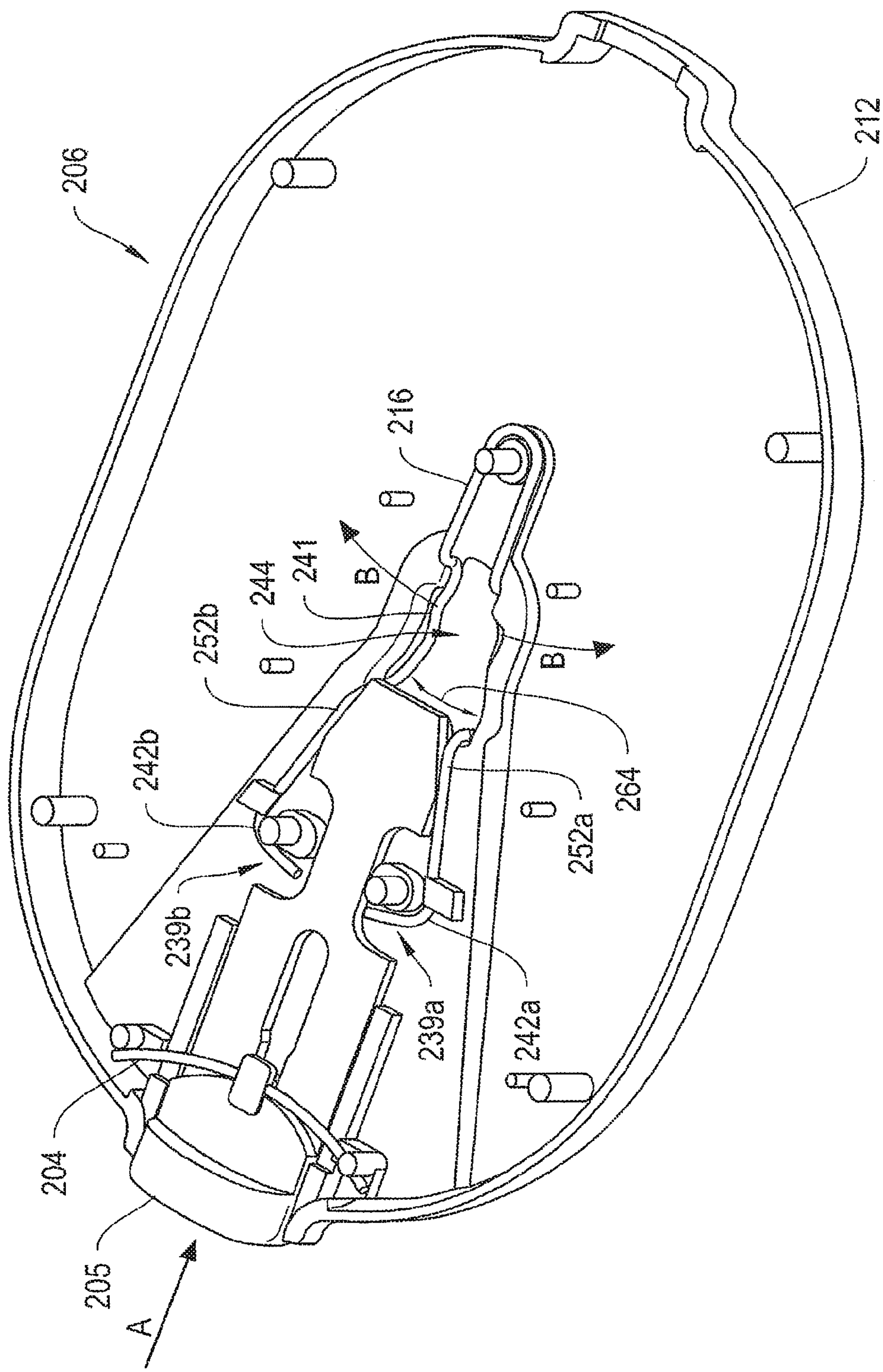

206
212
216
241
244
B
252b
B
242b
264
252a
239b
242a
239a
204
205
A

FIG. 9E

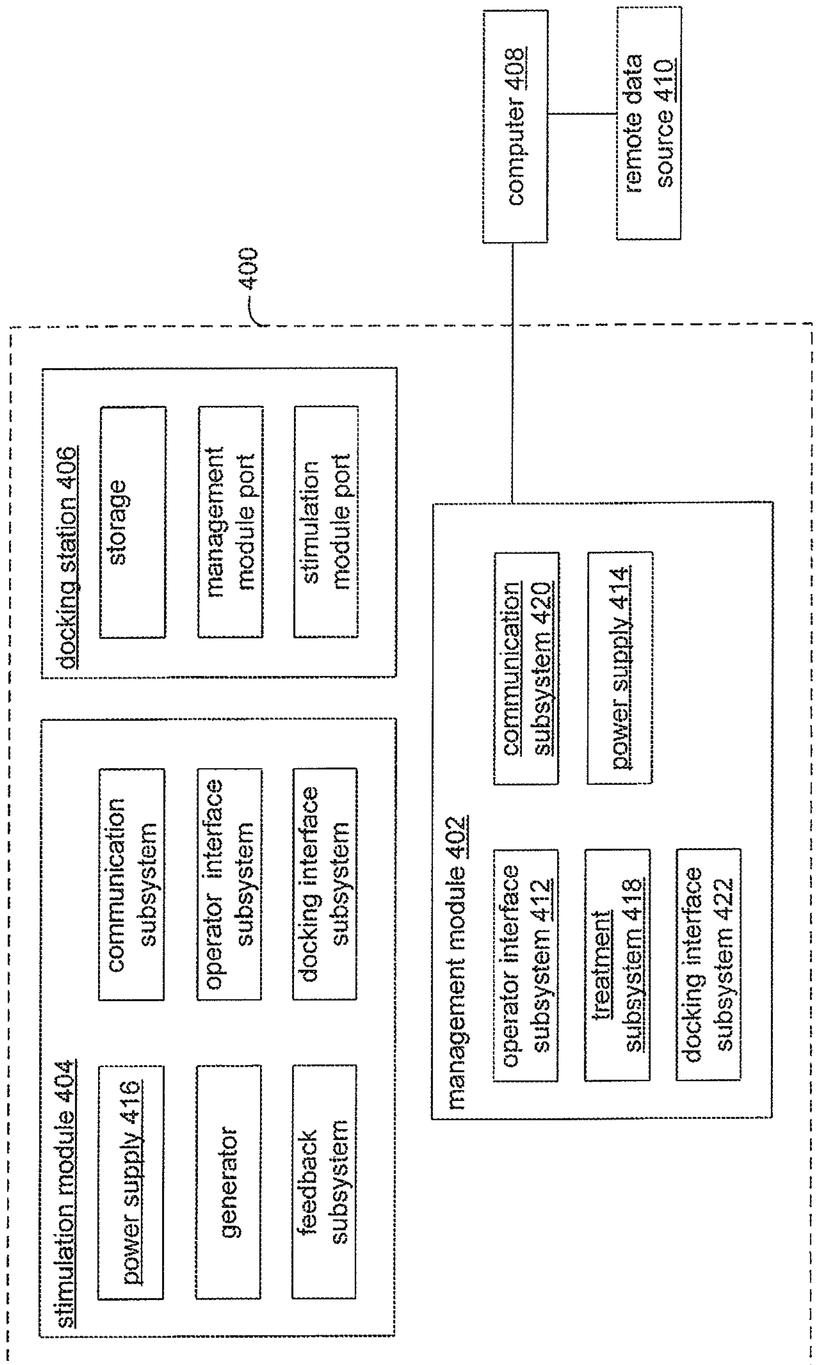

400
docking station 406
storage
management module port
stimulation module port
stimulation module 404
power supply 416
generator
feedback subsystem
communication subsystem
operator interface subsystem
docking interface subsystem
management module 402
operator interface subsystem 412
treatment subsystem 418
docking interface subsystem 422
communication subsystem 420
power supply 414
computer 408
remote data source 410

FIG. 10

LOW PROFILE CONNECTOR SYSTEM

INCORPORATION BY REFERENCE TO ANY PRIORITY APPLICATIONS

Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND

Electro-stimulation is widely used for pain relief, for muscle strengthening and conditioning, wound healing, and other medical rehabilitative and prophylactic purposes. An electrode (e.g., adhesive electrode) is placed on a user's skin near where the treatment is sought. In currently available systems, the electrode is connected to a wire that connects to a stimulator. Current devices tend to be bulky and have wires that get tangled or in the way of the user, which is intrusive to the user's daily activities. Due to the bulkiness of the device, it is also difficult to wear the device under clothing.

In addition, many current devices are complex and lack a simple, user-friendly connection mechanism between the stimulation device and an electrode to allow the user to easily connect or disconnect the device. The drawbacks of current electro-stimulation devices prevent the user from seamlessly integrating electrical stimulation therapy into their everyday lives. Also, if the electrode is placed in a hard to reach or non-visible body part (e.g., back of a patient's thigh), many devices are ill-equipped for seamless connection between the electrode and the stimulator device. As a result of the foregoing problems, user compliance is often poor.

One additional acute problem with existing connectors is that they are typically applied using a vertical connecting force. A vertical force can be painful when applied to electrodes used to treat tissue that has been burned or otherwise injured or subject to pain.

SUMMARY

The systems and methods described herein address the deficiencies in the prior art by providing low profile electrical connectors for connecting to an electro-stimulation interface having an improved connection mechanism that is easier to use, less intrusive to the user's daily activities, and less painful to apply to injured tissue. Methods of manufacturing such connectors are also disclosed. In general, the systems disclosed herein provide an electrical connector having a first side-entry portal as part of the connector housing, which portal receives an electrically conductive element, such as an electrode, and guides it within the housing along a path that generally extends parallel to the user treatment site. That configuration facilitates a lower profile connection system that is easier to use and also potentially less painful to users who have suffered severe burns or other injuries or pain. In exemplary systems a low profile electrical connector is provided with a housing having exterior perimeter sides, top and bottom surfaces and a side-entry guide channel disposed along the bottom surface. An opening configured to receive the electrically conductive element is disposed along the exterior perimeter side and in communication with the channel. The channel guides the electrically conductive element within the housing. The connector also includes a receptacle positioned within the housing and having an electrically conductive surface that forms an interface with the electrically conductive element. In certain implementations, the connector includes a plurality of side-entry portals along an exterior perimeter side for receiving the electrically conductive element. In certain implementations, the housing includes a transceiver that is configured to receive and/or transmit signals to a control device for stimulating muscle or nerve. The low-profile connector system described herein is configured to laterally engage the electrically conductive element. The connector system is preferably configured to be controlled wirelessly. In certain implementations, a plurality of connector systems are used, which may be connected by a flexible cable or wire. Additionally, the improved connector system allows a user with sensitive skin or wound to connect the stimulation device to the electrically conductive element positioned on sensitive skin areas without applying vertical connecting force.

In certain systems, the connector also includes a release actuator that is operatively engaged to the receptacle and configured to extend a force along a plane substantially parallel with the guide channel to disengage the electrode or other electrically conductive element from the receptacle. Upon actuating the release actuator, the electrically conductive element is removed from the receptacle when the housing is pulled away from the electrically conductive element along the guide channel.

In certain implementations, the side-entry guide channel may be formed at least in part by an interior wall that extends from the opening towards the receptacle. In certain implementations, pulling the receptacle away from the electrically conductive element along the guide channel disengages and removes the electrically conductive element from the receptacle. Optionally, the guide channel is defined at least in part by the bottom surface of the housing, and during disengagement the housing is pulled away from the electrically conductive element along an interior wall. The guide channel may include a path that tapers within the receptacle.

Optionally and alternatively, the receptacle of the connector includes one or more compressible legs that are operable by a release actuation to adjust the size of the channel and, thereby, insertion and release of the electrically conductive element. In certain implementations, the connector includes an upper leg, a vertically disposed post leg, and a leading leg configured to guide the electrically conductive element from the side-entry guide channel. The vertically disposed post legs are spaced apart from one another and configured to maintain space between the legs throughout operation. In certain implementations, a connector is provided with a release actuator configured to release the electrically conductive element from the receptacle. The release actuator is laterally engaged to the receptacle and adapted to move the upper legs of the receptacle away from one another in response to the actuation of the release actuator. In certain implementations, the side-entry guide channel extends between the leading leg and the upper leg.

Methods of assembling and using an electro-stimulation connector according to the disclosed technology are also provided.

Various alternative embodiments and sub-features are also disclosed herein with respect to the low profile electrical connectors, as will become apparent in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The following figures depict illustrative embodiments in which like reference numerals refer to like elements. These depicted embodiments may not be drawn to scale and are to be understood as illustrative and not as limiting.

FIG. **1**A depicts an electrode placed on a user's body and a connector configured to engage the electrode.

FIG. **1**B depicts an exemplary mating relationship between the electrode and the connector of FIG. **1**A.

FIG. **2**A shows a bottom-perspective view of an exemplary electrode connector.

FIG. **2**B shows a bottom view of an alternative embodiment of an exemplary electrode connector.

FIG. **2**C shows a bottom view of an alternative embodiment of an exemplary electrode connector.

FIG. **3** shows a front view of the connector of FIG. **2**A.

FIG. **4** shows a top-perspective view of the connector of FIG. **3** without a top cover.

FIG. **5** shows a bottom-perspective view of a receptacle connected to a electrode connector.

FIGS. **6**A-**6**C show various views of an electrode connector engaging an electrode, according to illustrative embodiments.

FIG. **7** shows the electrode of FIG. **5** received within a connector.

FIG. **8** shows the connector and electrode of FIG. **7** being disengaged from one another.

FIG. **9**A shows an alternative embodiment of a connector having a release actuator engaging an electrode.

FIG. **9**B shows a bottom-perspective view of the connector of FIG. **9**A.

FIG. **9**C shows a top-perspective view of the connector as shown in FIG. **9**B without a top cover.

FIG. **9**D shows a perspective view of an exemplary receptacle housed within the connector of FIG. **9**C.

FIG. **9**E shows a top-perspective view of the connector of FIG. **9**C with the release actuator depressed.

FIG. **10** is a block diagram of an illustrative electrostimulation system.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

The systems and methods described herein provide connection systems that allow a simple yet effective connection between electrically conductive element, such as an electrode, and an electro-stimulation device. In particular, a low-profile connector that laterally engages an electrically conductive element (such as a snap electrode) is described. A lateral connection allows a clinician or user to engage the low-profile connector to an electrically conductive element placed on a user's body site by applying a force parallel directly to the body site. This may be particularly useful and beneficial to users with sensitive skin such as post-operative or burn patients.

To provide an overall understanding, certain illustrative embodiments will now be described, as more particularly set forth in the figures. However, one of ordinary skill in the art will understand that the systems and methods described herein may be adapted and modified for other suitable applications, and that such other additions and modifications are within the scope hereof.

Turning to the illustrative embodiments, FIG. **1**A shows an exemplary embodiment of a low profile connector **100** positioned to laterally engage an electrically conductive element **102** placed on the back of a user's calf. Some users may have difficulty connecting the connector **100** to electrodes or other electrically conductive elements placed in areas that are not easily visible or accessible. The connector **100** engages the electrically conductive element **102** along the surface of the user's skin in direction noted by Arrow A. Connection along that path may be easier to perform than along a vertical path.

As shown in FIG. **1**B, the electrically conductive element **102** is a snap-type electrode having an active surface **103** which may be coated with a self-adhesive material or self-adhesive film (not shown) that sticks to a user's body site. The element **102** may alternatively be a sensor, or other conductive element, such as conductive embroidery in a user's clothing, provided it is positioned and configured with a stud or other conductive interface that enables it to make electrical contact with the connector **100**. Exemplary conductive embroidery elements may include silver, copper or other metal (or conduct polymer) sewn or glued to the surface of a user garment, such as an exercise sock, t-shirt, or a brace, and having a stud or other conductive surface exposed and positioned to mate with the connector **100**. In certain implementations, the electrode **102** is manufactured to have metallic or other conductive extensions from its sides, which extensions fit within pockets in the garment or are sewn within the garment, while the stud remains exposed for connection to the connector **100**. The electrically conductive element shown as element (depicted as an electrode) **102** may be disposable or reusable depending on a particular treatment protocol or condition to be treated. The electrode **102** also includes a stud portion **104** that protrudes from the active surface **103** for making electrical connection with the connector **100**. The connector **100** is depicted in FIG. **1**B in relation to a plane **105** that extends axially through the connector and substantially parallel to the user's body site. As shown in FIG. **1**B, the connector **100** travels laterally along the plane **105** in direction A until the electrode **102** engages within the connector **100**. In certain implementations the connector contacts the user's tissue during lateral engagement, while in others the connector moves parallel to the user's body site but remains above it, without contacting the body site.

As shown in FIG. **2**A, a bottom-perspective view of the connector **100**, the connector **100** includes a housing **106** having exterior perimeter side **112** that extend around the perimeter of the housing **106**, a bottom surface **110** configured to extend along or parallel to a user's body site (such as the skin surface), and a top surface **108** spaced above the bottom surface **110**. The connector **100** also includes a side-entry guide channel **114** defined at least in part by the bottom surface **110** of the housing **106**. The guide channel **114** is adapted to self-guide the connector **100** with respect to the electrode **102**. The guide channel **114** includes an opening **120** positioned along the exterior perimeter side **112** for receiving and guiding the electrode **102** within the housing **106**. The guide channel **114** extends from the opening **120** to a receptacle pocket **122** of the housing **106**. The receptacle pocket **122** houses a receptacle **116** and is formed on the bottom surface **110** of the housing **106**. The receptacle **116** is disposed within the housing **106** and includes an electrically conductive element that receives the electrode **102** forming an electrical/mechanical connection between the electrode **102** and the connector **100**, as described more fully below.

In certain implementations, the connector includes more than one side-entry guide channel. For example, as shown in FIG. **2**B, which shows a bottom view of an alternative embodiment of the connector **100**, a connector **100***a* includes a plurality of guide channels **114** disposed along the exterior perimeter side **112** for receiving an electrically conductive element such as an electrode. Although shown with four guide channels **114-114** in FIG. **2**B, the connector **100***a* may include two, three or more guide channels depending on the treatment protocol or condition to be treated. Having a plurality of guide channels allows the user to engage an electrically conductive element (e.g., an electrode) in multiple ways, which may improve usability and user satisfaction, Variations on the structure of one or more of the guide channels may be made, as desired for adaptation to particular systems. For example, multiple such channels may connect to a single receptacle that can receive the electrode from any of the channels. FIG. **2**C illustrates an example having a connector **100***b* including a plurality of guide channels **114** leading to a single receptacle **116***a*. The receptacle **116***a* includes first and second openings **117***a* and **117***b*, respectively, for receiving an electrically conductive element such as an electrode.

The side entry guide channel **114** is defined at least in part by the interior walls **130***a* and **30***b* that extend from the opening **120** towards the receptacle **116**. As shown, the interior walls **130***a* and **130***b* form a V-shaped path that tapers into the receptacle **116**. Such configuration allows the user to guide the electrode **102** within the housing **106**, as the interior walls **130***a* or **130***b* slide against the stud **104** when the housing **106** moves laterally in direction A (as shown in FIG. **1**B). The guide channel **114** also includes angled regions **132***a* and **132***b* of walls **130***a* and **130***b*, respectively, that further guide the electrode within the housing **106**. FIG. **3**, which depicts a front view of the housing **106**, shows the angled wall regions **132***a* and **132***b* extending from respective end points **131***a* and **131***b* of the respective interior walls **130** and **130***b* to the receptacle pocket **122**. The angled walls **132***a* and **132***b* receive the stud **104** as the stud **104** travels along the interior wall **130***a* or **130***b* and further guide the stud **104** into the receptacle **116**. As shown, the height h_1 of the interior wans **130***a* and **130***b* increases from the opening **120** to height h_2 near the angled walls **132***a* and **132***b*. This ramped configuration creates a deeper channel for receiving and guiding the electrode **102** as the electrode **102** travels towards the receptacle **116**. The guide channel **114** also includes an upper guiding surface **136** that is partly defined by the interior and angled walls. The upper guiding surface **136** and the interior and angled walls form a space for receiving and guiding the electrode **102** within the connector **100**. The upper guiding surface **136** may extend at an angle with respect to the bottom surface **110** of the housing **106**, or it may also extend substantially parallel to the bottom surface **110** of the housing **106**.

In certain implementations, the housing **106** includes an angled bottom surface **111** that co extends with the bottom surface **110**. In certain implementations, the angled bottom surface **111** slopes upwardly from the middle portion of the housing **106** towards the opening **120**. FIG. **3** shows an embodiment of the angled bottom surface **111**. The angled bottom surface **111** may allow the user to better engage the electrode **102** by allowing for more ergonomic placement of the connector **100**. For example, when the user first places and slides the angled bottom surface **111** against the user's skin surface, the user may hold the connector **100** at an angle with respect to the user's skin surface. This may be more natural or ergonomic to some users.

FIG. **4** shows a top-perspective view of the housing **106**. For clarity, the housing **106** is shown without the inner electronic components (e.g., PCB, battery). The housing **106** includes a receptacle connector **126** that connects the receptacle **116** to the housing **106**. As shown, the receptacle connector **126** is a separate component and includes holes **128***a* and **128***b* that receive the receptacle to the housing **106**. The receptacle connector **126** is also shaped to follow the contour of the top surface **108** of the housing **106**. The receptacle connector **126** mates with a plurality of positioning posts **133***a*-**133***f*, which are affixed to the housing **106**. The receptacle connector **126** may be made of metallic material that can transfer electrical pulses from a controller (not shown) to the receptacle **116**.

In certain implementations, the receptacle **116** includes one or more compressible legs that are operable by a release actuation to adjust the size of the channel and, thereby, insertion and release of the electrode. As shown in FIG. **5**, the receptacle **116** includes a pair of guide legs **140***a* and **140***b*, an electrode receiving pocket **138** for receiving and making electrical connection with the stud **104**, and a neck portion **139** that bridges the guide legs to the electrode receiving pocket **138**. As shown, the guide legs **140***a* and **140***b* and the electrode receiving pocket **138** are depicted in relation to a plane **142**, which is substantially parallel to the bottom surface **110** of the housing **106**. The guide legs **140***a* and **140***b* taper from their respective open ends **141***a* and **141***b* toward the neck portion **139**. This shape helps to channel the stud **104** towards the electrode receiving pocket **138** during the engagement process. The receptacle **116** is made of spring steel wire that opens and closes responsive to the direction and the amount of the force applied. For example, as the stud **104** travels along the guide legs **140***a* and **140***b*, the stud **104** forces open the guide legs **140***a* and **140***b* slightly outwardly to create space for the stud **104** to travel and enter the electrode receiving pocket **138**. The receptacle **116** also includes a pair of vertical post legs **144***a* and **144***b* that extend perpendicular to the working plane **142** and a pair of upper legs **146***a* and **146***b* that connect the vertical post legs **144***a* and **144***b* to the receptacle connector **126**. These vertical post legs are spaced apart from one another initially and are configured to maintain space between the legs throughout the operation. As shown in FIG. **5**, the upper legs **146***a* and **146***b* are received by holes **128***a* and **128***b* and extend substantially parallel to the working plane **142**. In some embodiments, the guide channel **114** extends between the guide legs **140***a* and **140***b* and the upper legs **146***a* and **146***b*.

When the user is ready to apply electro-stimulation to a desired body site, the electrode **102** is placed on the user's body site and the connector **100**, which may be wirelessly programmed, is initially positioned near the electrode **102**. FIG. **6**A shows a perspective view of the connector **100** ready to engage the electrode **102**. As shown, the housing **106** includes an entry region **134** defined by the side entry guide channel **114** with opening **120**. The entry region **134** receives the electrode **102** when the user initially engages the connector **100** to the electrode **102**. The entry region **134** is shaped to capture the stud **104** without the user having to closely align the connector **100** with respect to the electrode **102**.

In operation, the user brings the connector **100** near the electrode **102** and slides the connector **100** laterally towards the electrode **102** so that stud **104** passes through opening **120**. Initially, the electrode **102** is received by the entry region **134**, which extends widely along the exterior perimeter side **112**, allowing the user to roughly position the connector **100** with respect to the electrode **102**. Because the entry region **134** has a large width, the user does not need to be precise when initially engaging the connector **100** to the electrode **102**. This is especially helpful for users who have reduced mobility/dexterity or if the body site is located where visual contact is difficult. After the electrode **102** enters the entry region **134** through the opening **120**, the channel facilitates the seating of the electrode within the connector **100** through various exemplary mechanisms. In certain implementations, a top surface **150** of the stud **104** engages an upper guiding surface **136** of the guide channel **114**, as shown in FIG. **6**B. As the user continues to laterally push the connector **100** towards the electrode **102** (e.g., along direction A), the upper guiding surface **136** of the connector **100** moves along the top surface **150** of the stud **104**. The interior walls **130***a* and **130***b* may also act as a "rail" for the stud **104** to travel, which gives the user the feeling of tracking or guiding during the engagement process. As shown, for example, in FIG. **6**C, which depicts the bottom view of the connector **100**, a side surface **152** of the stud **104** may initially engage a narrow end **129***a* of the interior wall **130***a* and travels along the interior wall **130***a* (path P**3**). The stud **104** may similarly travel along the interior wall **130***b* and angled wall region **132***b*, as depicted by path P**1** shown in FIG. **6**C.

Alternatively, as depicted by path P**2**, the stud **104** may travel straight into the receptacle **116** without engaging the interior or the angled walls. As depicted by path P**4**, the electrode **102** may also travel along a curved path. These paths are depicted for illustrative purpose only. The electrode **102** may travel in any combination of straight and curved paths within the guide channel **114**. Once the electrode **102** is guided and positioned within the receptacle **116**, the user may hear an audible click or, in some embodiments, a visual indicator (e.g., ON/OFF light) provided on the top cover **118** of the connector **100** to indicate that the device is ready to be used.

FIG. **7** shows an exemplary bottom view of the electrode **102** fully engaged to the receptacle **116** that is housed within the connector **100**. As shown, the stud portion **104** of the electrode is sized such that it can be received within the electrode receiving pocket **138** of receptacle **116**. Together with the neck portion **139**, the shape and size of the electrode receiving pocket **138** secure the electrode **102** while the device is in use.

When the user is ready to disengage the connector **100** from the electrode **102**, the connector **100** is laterally pulled away from the electrode **102** along the guide channel **114** in a direction opposite to the engagement direction. This pulling motion disengages and removes the electrode **102** from the receptacle **116**. In particular, as shown in FIG. **8**, when the connector **100** is pulled along direction E, the stud **104** releases from the electrode receiving pocket **138** as the pulling force exceeds the retaining force of the neck portion **139**. As that occurs, the guide legs **140***a* and **140***b* open outwardly (see Arrows C depicting the outward direction) and release the stud **104** from the guide legs **140***a* and **140***b*. The stud **104** then travels along the interior wall **130***a* or **130***b* following the release. Alternatively, and similar to the entry path (e.g., P**1**-P**4**) depicted in FIG. **6**C, the electrode **102** may exit the guide channel **114** along the upper guiding surface **136**, the interior walls **130***a* or **130***b*, or the angled wall region **132***a* or **132***b*. In some embodiments, after the housing **106** is laterally pulled away from the electrode, the housing **106** is disengaged vertically as soon as the stud **104** is released from the guide legs **140***a* and **140***b*.

The ease of engaging and disengaging the connector **100** from the electrode **102** may vary, depending on the stiffness, size, and shape of the material that form the receptacle **116**. In some embodiments, the receptacle **116** has a constant diameter throughout the part, which may range from about 0.4 mm to about 1 mm. The diameter may be smaller or larger depending on the condition to be treated. In some embodiments, the guide legs **140***a* and **140***b*, the neck portion **139**, and the electrode receiving pocket **138** have varying diameters to reduce the likelihood of premature disengagement of the connector **100** from the electrode **102**. For example, the neck portion **139** may have a larger diameter than the electrode receiving pocket **138**, which may enable the receptacle **116** to enclose the electrode **102** with stronger force to prevent inadvertent disengagement of the connector **100** from the electrode **102**.

The user can engage and disengage the connector **100** using only one hand, as the connector **100** is easily laterally slidable towards and away from the electrode **102** without requiring the user to first orient the connector **100** with respect to the electrode **102**. The top cover **118** of the connector **100** may be ergonomically shaped to provide grip surfaces for the user to hold and manipulate the connector **100**. The top cover **118** may be screwed or glued to the housing **106**. The top cover **118** and the housing **106** are preferably made of plastic or any other suitable material that provides adequate protection to inner components housed within the housing **106**. The top cover **118** may be snap fitted to the housing **106**.

FIGS. **9**A and **9**B show an electrical connector **200** including a release actuator **202** for opening and closing a receptacle **216** to thereby engage and disengage the electrode **102**. Similar to the connector **100**, the connector **200** engages the electrode **102** by laterally traveling along the user's body site. The connector **200** includes a housing **206** having a bottom surface **210**, a top surface **208**, an exterior perimeter side **212**, and a side-entry guide channel **214** having an opening **220** for receiving and guiding the electrode **102**. The guide channel **214** also includes interior walls **230***a* and **230***b*, angled walls region **232***a* and **232***b*, and an upper guiding surface **254** for guiding the electrode **102** towards the receptacle **216**, similar to the engagement described earlier with respect to the electrode **102** and the connector **100**.

As shown, the release actuator **202** is engaged to the receptacle **216** near the opening **220** and when actuated, it applies a force along a plane substantially parallel with the guide channel **214** to disengage the electrode **102** from the receptacle **216**. As more particularly shown in FIG. **9**B-**9**C, the release actuator **202** is operable between open (i.e., actuated) and closed (i.e., non-actuated) positions. In the closed position, the release actuator **202** is not actuated, thus no force is applied by the release actuator **202**. However, the release actuator **202** is preferably biased to stay in the closed position. As shown in FIG. **9**C, the housing **206** includes an actuator slot **203** configured to house the release actuator **202**. The actuator slot **203** may be disposed through the exterior perimeter side **212** of the housing **206**. The actuator slot **203** includes an entry end **218**, an exit end **211**, and an actuator receiving surface **213** that extends between the entry end and the exit end. The release actuator **202** slides along the actuator receiving surface **213**. In the closed position (shown in FIG. **9**C), a release button **205** of the release actuator **202** protrudes distance t from the exterior perimeter side **212**, which allows the user to tactilely locate the push button **205** even when the connector is positioned in a non-visible body part. The distance t represents the maximum travel distance of the release actuator **202** during use. As illustrated, the push button **205** has a low profile, which allows the user to place the connector **200** anywhere around the user's body and reduce the likelihood of inadvertently actuating the push button **205** when moving.

The release actuator **202** is secured to the connector **200** by biasing bar **204**, which connects to receiving pocket **308** and top surface **302**. The biasing bar **204** is made of an elastic material such as steel wire that allows the biasing bar **204** to be bent when force is applied and return to its original shape when the force is removed. The two ends **217***a* and **217***b* of the biasing bar **204** rest against a pair of anchoring posts **207**, which are fixedly connected to the top surface **208** of the housing **206**. As shown, the center portion of the biasing bar **204** is received within the bar receiving pocket **308** of the release actuator **202** anchor the bar **204** to the housing **206**. The release actuator **202** is movable with respect to the housing **206**.

When the user is ready to engage the connector **200** to the electrode **102** to begin the electro-stimulation, the user may actuate a push button **205** of the release actuator **202** along the direction denoted by Arrow A (FIG. **9**C) to open the legs of receptacle **216** so it receives the electrode **102**.

As further illustrated in FIG. **9**C-**9**E, the release actuator **202** laterally engages and actuates the receptacle **216** to open and close, thereby receiving and releasing the electrode. The receptacle **216**, which is made of steel or other conducting wires, includes free ends **239***a* and **239***b* that are disconnected from one another. Such shape and the spring characteristics of the steel wire allows the receptacle **216** to be squeezed and released. When the receptacle **216** is squeezed, the free ends **239***a* and **239***b* move closer to another. When the receptacle **216** is released from the squeezed position, the free ends retreat back to their original positions (i.e., move away from one another). As shown in FIG. **9**C, the free ends **239***a* and **239***b* are bent about position posts **209***a* and **209***b*, which are fixed to the top surface **208** of the housing **206**. These posts **209***a* and **209***b* help align the receptacle **216** when the device is in use. The free ends **239***a* and **239***b* also connect to a pair of upper legs **242***a* and **242***b*, respectively. As shown, the free ends **239***a* and **239***b* and the upper legs **242***a* and **242***b* extend along a plane that is substantially parallel to the top surface **208**. In some embodiments, the free ends and/or the upper legs are disposed in a plane that is at an angle with respect to the top surface **208**. The free ends may also be bent at an angle with respect to the upper legs. The upper legs **242***a* and **242***b* are connected to the guide legs **240***a* and **240***b*, respectively, via connecting legs **241***a* and **241***b*. As shown, the guide legs **240***a* and **240***b* and the upper legs **242***a* and **242***b* lie in a plane that is substantially parallel but spaced, away from one another. The connecting legs **241***a* and **241***b* are fitted within a receptacle pocket **222** (FIG. **9**C) that is sized to house the guide legs **240***a* and **240***b* and the electrode receiving pocket **244** of the receptacle **216**.

The release actuator **202** includes contact surfaces **252***a* and **252***b* that engage the corresponding contact portions **243***a* and **243***b* of the upper legs **242***a* and **242***b* when the release actuator **202** is actuated, When the user depresses the button **205** of the actuator **202**, the contact surfaces **252***a* and **252***b* of the actuator **202** engage and push the upper legs **242***a* and **242***b* of the receptacle **216** away from one another in the direction denoted by Arrows B (FIG. **9**E). When this happens, the upper legs **242***a* and **242***b* move the guide legs **240***a* and **240***b* along the same direction to make room for the electrode **102** to pass through passageway **262**, which extends between the guide legs **240***a* and **240***b*. The guide legs **240***a* and **240***b* are initially spaced apart and are configured to maintain this spacing until the release actuator **202** is actuated to open the passageway a distance **262**. As noted above, the guide legs **240***a* and **240***b* are connected to the electrode receiving pocket **244**, which is sized and shaped to receive and engage the stud **104** of the electrode **102** during the electro-stimulation. The electrode receiving pocket **244** is connected to an anchoring end **246** for receiving a fastener (e.g., screw) to connect the receptacle **216** to the housing **206**.

FIG. **9**E shows an embodiment of the release actuator **202** opening the receptacle **216** when the user has pushed the push button **205** until it is flush with the exterior perimeter side **212** of the housing **206**. When this happens, the passageway **262** is widened to **264**, thereby allowing the electrode **102** to pass through the receptacle **216** more easily. As shown, the free ends **239***a* and **239***b* are moved further apart from one another, the electrode receiving pocket **244** is enlarged to receive the stud **104** of the electrode **102**. While holding down the push button **205**, the user may experience some resistance applied by the biasing bar **204**. As shown in FIG. **9**E, the biasing bar **204** is bowed slightly against the force applied by the user via the push button **205**. In some embodiments, the user may hold down the push button **205** while laterally moving the connector **200** against the user's body site. As described above, actuating the push button **205** opens the receptacle **216** to receive the stud **104** of the electrode **102**. As the connector **200** approaches near the electrode **102** laterally, the electrode **102** is received within the guide channel **214** and is guided by the various walls of the guide channel **214** to the electrode receiving pocket **244** of the receptacle **216**. After the electrode **102** is engaged to the receptacle, the user may release the push button **205**. When the button is released, which is biased against the spring force of the biasing bar **204**, the release actuator **202** returns to its original position as shown in FIG. **9**C. This forces the contact surfaces **252***a* and **252***b* of the release actuator **202** to retreat backwards to its original position and disengage contact with the corresponding contact portions **243***a* and **243***b* of the receptacle **216**, thereby narrowing the passageway **264** to **262**. With the stud **104** of the electrode **102** engaged within the electrode receiving pocket **244**, when the passageway returns to its original configuration, it acts as a gate that encloses the stud **104**. In some embodiments, the stud **104** is held within the electrode receiving pocket **244** until the release actuator **202** is actuated again to open the receptacle **216**. Following the completion of the electro-stimulation, the user may actuate the release actuator **202** to disengage the connector **200** from the electrode **102**. Upon actuating the release actuator **202**, the electrode **102** is removed from the receptacle **216** when the housing **206** is pulled away from the electrode **102** along the guide channel **214**.

In some embodiments, the user may "force" open the receptacle **216** during engagement. Similar to the connection between connector **100** and the electrode **102**, the user may take the connector **200** and laterally push along the user's body site without first actuating the release actuator **202**. In such configuration, manual force applied by pushing the connector **200** against the stud **104** of the electrode is sufficient to force open the receptacle **216**. Similar to the engagement between the connector **100** and the electrode **102** (FIG. **6**A), the stud **104** is initially received within the guide channel **214** and it travels along the interior walls **230***a* and/or **230***b* and angled walls **232***a* and/or **232***b*. The stud **104** is further guided to the electrode receiving pocket **244** via guide legs **240***a* and **240***b*. The force applied by the user opens the guide legs **240***a* and **240***b* and the stud **104** is pushed into the electrode receiving pocket **244**. The connector **200** is now ready for use. Following the completion of the electro-stimulation, the user may actuate the release actuator **202**, which enlarges the opening between the guide legs **240***a* and **240***b*, to disengage the connector **200** from the electrode **102**. The user may also manually pull the connector **200** opposite the engagement direction. Using the release actuator **202** to disengage the connector **200** may apply less force to the user's treatment area, which may be beneficial to users with sensitive skill or wound, particularly where the electrode is applied to that sensitive skin or wound area.

In some embodiments, the connectors **100** and **200** connect and disconnect vertically over the stud **104**. In such configuration, the connector is positioned near the stud **104** which includes a narrow waist **107** (FIG. **9**A) disposed between the top surface **150** and the active surface **103**. The narrow waist **107** of the electrode **102** receives a portion of pocket wires **245***a* and **245***b* (FIG. **9**D) when the connector is pushed vertically downward near the stud **104** during the engagement. When the user is ready to disengage the connector **100** or **200** from the electrode **102**, the connector **100** or **200** is vertically pulled away from the electrode **102**. This vertical pulling motion disengages the pocket wires **245**a and **245**b from the narrow waist **107** of the electrode **102** and releases the electrode **102** from the connector **100** or **200**.

In certain implementations, the connectors **100** and **200** include, among other things, a battery, a controller, an electrical circuitry, and a transceiver for receiving and sending data such as a treatment protocol to apply electrical stimulation to a user's body site. The transceiver is also configured to receive and/or transmit signals to a control device for stimulating nerves. FIG. **10** is a block diagram of an electrical stimulation system **400**, in accordance with certain embodiments. The system **400** includes a control module **402**, a stimulation module **404** and a docking station **406**. The diagram of FIG. **10** also includes a computer **408** which is capable of communicating with a remote data source **410**.

In certain implementations, the control module **402** provides an interface between the stimulation module **404** and an operator who wishes to control therapy applied to a user. An operator may be a care provider or the user him/herself. The control module **402** may transmit and receive information to and from the stimulation module **404** via a wireless communication protocol. The control module **402** may also allow an operator to navigate through an operator interface, select stimulation programs or protocols, set desired options and control the waveforms applied to the user. The control module **402** may also be capable of interfacing with the computer **408** in order to access the remote data source **410**.

FIG. **10** depicts a number of subsystems that may be included in the control module **402**. In certain implementations, an operator interface subsystem **412** allows an operator to adjust the treatment provided to a user by the system **400**, view current operating parameters, view historical user data (such as performance and use statistics), view current physiological parameters (such as muscle feedback signals), and adjust the capabilities of the system **400** (e.g., by downloading additional programs to the control module **402** from the remote data source **410**).

The control module **402** includes a power supply **414**. The power supply **414** may be any suitable source of energy for powering the components of the control module **402**. The power supply **414** may be a battery, or an AC power supply (such as a standard wall power supply). The power supply **414** may include a solar cell, a thermal cell or a kinetic cell capable of converting motion energy to electrical energy for powering the control module **102**. It will be noted that the control module **402** may contain multiple power supplies, any of which may be any of the power supplies described herein.

The control module **402** (as well as any device or system component described herein) may include memory for storing basic operating parameters (e.g., pre-stored sounds, volume, display parameters, time and date) and/or supporting any of the subsystems described in detail below. The control module **402** may use memory for storing statistics regarding usage of the control module **402**. For example, information such as type of program, date and frequency of treatments, and intensities applied may be recorded in memory. In an embodiment, usage statistics are uploadable from memory to the remote data source **410** when the control module **402** is in communication with the remote data source **410** (e.g., via the computer **408**).

The control module **402** may include a treatment subsystem **418**. The treatment subsystem **418** may include circuitry for communicating with any one or more of the other subsystems and components of the control module **402**, including the operator interface subsystem **412**, the communication subsystem **420**, and the feedback subsystem **422**. The treatment subsystem **418** may include memory for storing one or more stimulation protocols and/or programs for electrical stimulation. The memory coupled to the treatment subsystem **418** is capable of storing at least **15** different stimulation protocols or programs.

It is to be understood that the forgoing description is merely illustrative. While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems, components, and methods may be embodied in many other specific forms without departing from the scope of the present disclosure.

The invention is not to be limited to the details given herein but variations and modifications will occur to those of skill in the art after reviewing this disclosure. The disclosed features may be implemented in sub-combinations with one or more other features described herein. For example, a variety of systems and methods may be implemented based on the disclosure and still fall within the scope. Also, the various features described or illustrated above may be combined or integrated in other systems or certain features may be omitted, or not implemented.

Examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could he made without departing from the scope of the information disclosed herein. Certain particular aspects, advantages, and modifications are within the scope of the following claims, All references cited herein are incorporated by reference in their entirety and made part of this application.

What is claimed is:

1. An electrical connector comprising:
- a housing including an exterior perimeter side and a bottom surface;
- a guide channel formed in the housing, the guide channel including
  - a first interior wall extending from a first side of a side opening in the exterior perimeter side to a receptacle,
  - a second interior wall extending from a second side of the side opening to the receptacle, and
  - an upper guiding surface extending between the first and second interior walls from a top edge of the side opening to the receptacle and above a bottom opening in the bottom surface; and
- the receptacle configured to electrically interface with an electrically conductive element.

2. The electrical connector of claim **1**, wherein a width of the guide channel between the first and second interior walls decreases from the side opening to the receptacle.

3. The electrical connector of claim **2**, wherein each of the first and second interior walls includes a first portion that tapers inward and a second portion having an angled region, the angled region having a greater inward taper than the first portion.

4. The electrical connector of claim **1**, wherein a height of the first and second interior walls increases from the side opening to the receptacle.

5. The electrical connector of claim **1**, wherein the upper guiding surface is inclined relative to the bottom surface, the incline increasing from the side opening to the receptacle.

6. The electrical connector of claim **1**, wherein the guide channel is configured to guide the electrically conductive element from the side opening to the receptacle.

7. The electrical connector of claim **6**, wherein the upper guiding surface is configured to contact a top surface of the electrically conductive element to guide the electrically conductive element from the side opening to the receptacle.

8. The electrical connector of claim **7**, wherein each of the first and second interior walls is configured to contact a side surface of the electrically conductive element to guide the electrically conductive element from the side opening to the receptacle.

9. The electrical connector of claim **1**, wherein the receptacle comprises a first leg and a second leg, the first leg and the second leg configured in size and shape to form a receptacle opening, a receiving pocket, and a neck portion between the receptacle opening and the receiving pocket.

10. The electrical connector of claim **9** wherein the first leg and the second leg are movable between a first closed position when the electrically conductive element is positioned in an area between the receptacle opening and the neck portion, a first open position when the neck portion is widened when the electrically conductive element is positioned within the neck portion, and a second closed position in which the neck region is narrowed with respect to the first open position when the electrically conductive element is positioned within the receiving pocket and thereby retained within the receptacle.

11. The electrical connector of claim **9**, further comprising a release actuator operatively engaged to the receptacle, wherein the release actuator applies a force along a plane substantially parallel with the bottom surface to disengage the electrically conductive element from the receptacle.

12. The electrical connector of claim **1**, wherein the bottom surface is configured to extend along a user's body site.

13. An electrical connector comprising:

a housing including an exterior perimeter side and a bottom surface;

a guide channel formed in the housing, the guide channel including a first interior wall extending from a first side of a side opening in the exterior perimeter side to a receptacle and a second interior wall extending from a second side of the side opening to the receptacle, the width of the guide channel between the first and second walls narrowing from the side opening to the receptacle,

the receptacle configured to electrically interface with an electrically conductive element, a release actuator operatively engaged to the receptacle, wherein the release actuator applies a force along a plane substantially parallel with the bottom surface to disengage the electrically conductive element from the receptacle.

14. The electrical connector of claim **13**, wherein the each of the first and second interior walls includes a first portion that tapers inward and a second portion having an angled region, the angled region having a greater inward taper than the first portion.

15. The electrical connector of claim **13**, wherein a height of the first and second interior walls increases from the side opening to the receptacle.

16. The electrical connector of claim **13**, wherein the guide channel is configured to guide the electrically conductive element from the side opening to the receptacle.

17. The electrical connector of claim **13**, wherein each of the first and second interior walls is configured to contact a side surface of the electrically conductive element to guide the electrically conductive element from the side opening to the receptacle.

18. The electrical connector of claim **13**, wherein the receptacle comprises a first leg and a second leg, the first leg and the second leg configured in size and shape to form a receptacle opening, a receiving pocket, and a neck portion between the receptacle opening and the receiving pocket.

19. The electrical connector of claim **18**, wherein the first leg and the second leg are movable between a first closed position when the electrically conductive element is positioned in an area between the receptacle opening and the neck portion, a first open position when the neck portion is widened when the electrically conductive element is positioned within the neck portion, and a second closed position in which the neck region is narrowed with respect to the first open position when the electrically conductive element is positioned within the receiving pocket and thereby retained within the receptacle.

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